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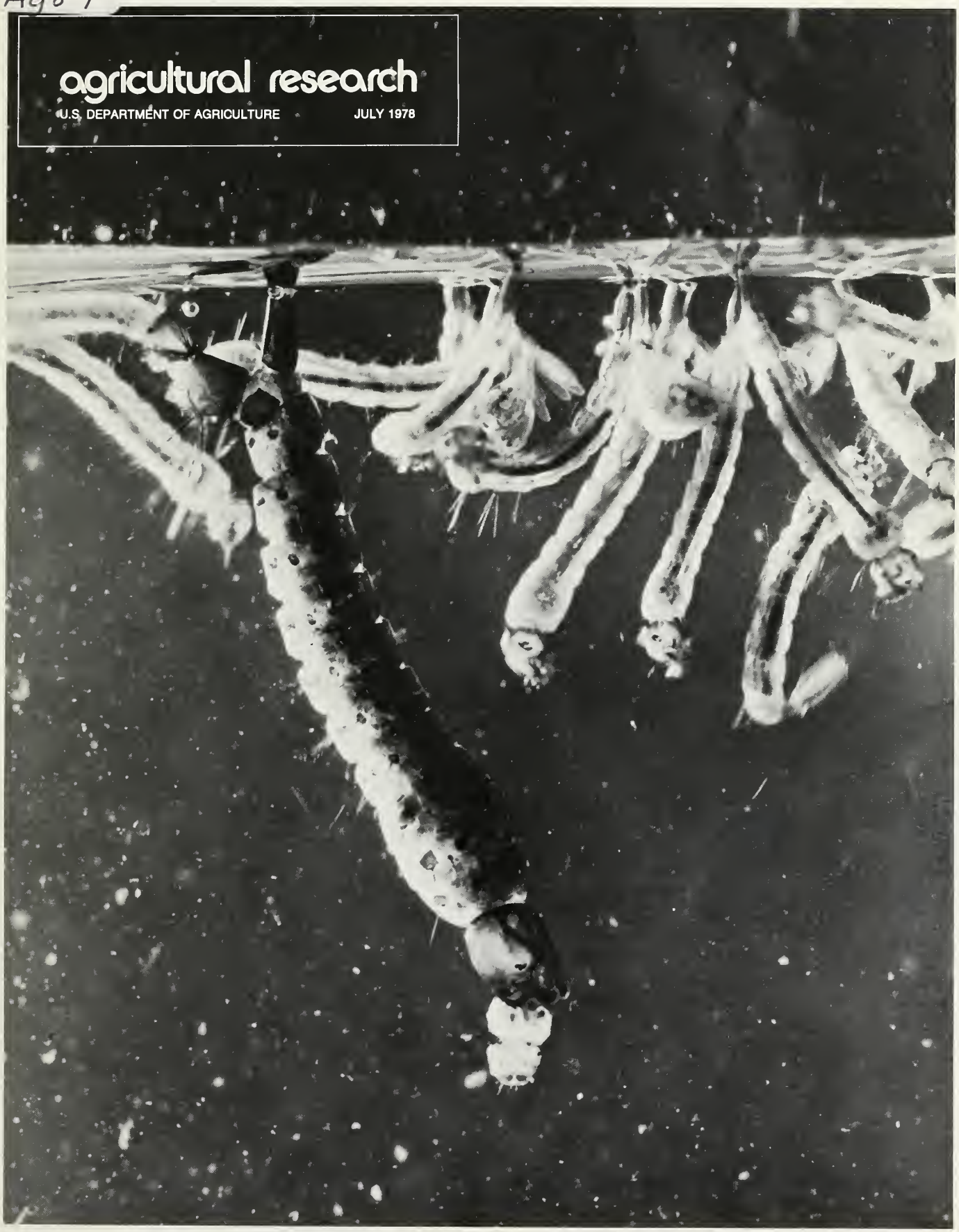

agricultural research

July 1978/Vol. 27, No. 1

Solar Energy—One Hope for the Future

In 1973, one year before the Arab oil embargo, the United States imported 36.1 percent of its total oil supply. At that time, oil cost $4.91 per barrel. In 1974, oil jumped to $13.69 per barrel and U.S. production declined for the first time. Last year, we imported 47 percent of our total oil supply, and that oil cost us between $14 and $15 per barrel. Our supplies of natural gas are becoming increasingly expensive and, in fact, this energy source is not available in some communities. Clearly, America needs additional energy options.

And, if America needs more options, no Americans need them more than those who raise our food. For the cost of energy is interwoven into the cost of our agricultural products.

Fortunately for us all, a post petroleum era has started to arrive; but like the sun in beginning a new dawn, the new solar age is slow in beginning here. For example: about 30,000 American homes heat their water with sunlight. But in Israel, that figure is 200,000, and in Japan, over two million homes have solar water heaters. In northern Australia, where the morning sun rises at least 13 hours before it reaches our eastern shore, the law requires solar heaters on all new buildings.

But if the sun of the solar dawn has risen earlier in other countries, its appearance on our horizon has not caught us napping. American agricultural scientists are working on an impressive array of solar tools: solar powered grain dryers, solar heated poultry, hog, and dairy houses, solar heated greenhouses, solar processes to cure burley tobacco, and even a photovoltaic cell powered insect trap. Solar heated and cooled homes designed for rural families have been developed. Fresnel lenses, the subject of recent SEA research, hold the promise of augmenting the efficiency of many other solar projects.

American farmers are turning to the sun for the answers to the energy problems that confront them: diminishing and increasingly expensive fossil fuels, the need for a clean, dependable energy source, the assurance that the energy they need will be there in the quantities they need it, and at a stable and predictable cost.

The dawn of the post petroleum era has found American agriculture wide awake. And that is not surprising. The ingenuity behind the new technology has been a part of American agriculture for a long, long time.—*R.W.D.*

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COVER: Larva of Toxorhynchites *rutilus rutilus*, a large, non-biting, predatory mosquito, devours larva of notorious *Aedes aegypti*—dread carrier of yellow fever virus. SEA entomologists in Gainesville, Fla., are studying *Tx. r. rutilus* as a biological control agent against *Aedes aegypti* and other disease-bearing mosquitoes. (*Tx. r. rutilus:* 17 mm; *A. aegypti:* 6 mm.) (0478X430–33).

AGRICULTURAL RESEARCH is published monthly by the Science and Education Administration (SEA), U.S. Department of Agriculture, Washington, D.C. 20250. The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through June 15, 1982. Yearly subscription rate is $6.50 in the United States and countries of the Postal Union, $8.15 elsewhere. Single copies are 55 cents domestic, 70 cents foreign. Send subscription orders to Superintendent of Documents, Government Printing Office, Washington D.C. 20402. Information in this magazine is public property and may be reprinted without permission. Prints of photos are available to mass media; please order by photo number.

Bob S. Bergland, Secretary
U.S. Department of Agriculture

James Nielson, Acting Director of Science and Education

Predatory Mosquitoes - Weapon Against Yellow Fever

LIKE perfume or pepper, synthetic pesticides can be "too much of a good thing." In the battle against disease-bearing mosquitoes, extensive use of pesticides results in the phenomenon of resistance to them.

For this reason scientists are reconsidering mosquito control strategies involving biological control agents such as the genus *Toxorhynchites*. Entomologist Jack A. Seawright says, "*Toxorhynchites rutilus rutilus* may hold more potential for control of the yellow fever mosquito than any other biological control agent we have considered."

Tx. r. rutilus is a large non-biting mosquito whose larvae prey on other species of mosquito larvae that breed in discarded cans and bottles, water cisterns, and tree holes. Mass, inundative releases of *Tx. r. rutilus* would reach these breeding sites, acting as a natural, predatory enemy.

To determine the potential usefulness of the species, *Tx. r. rutilus* was colonized and then studied in the SEA Insects Affecting Man and Animals Research Laboratory.

When *Tx. r. rutilus* larvae were reared at an average of 28° C in individual containers with a surplus of mosquitoes (*Aedes aegypti*) as prey, it took 1.6, 15.6, and 6.0 days for eggs, larvae, and pupae to develop, respectively.

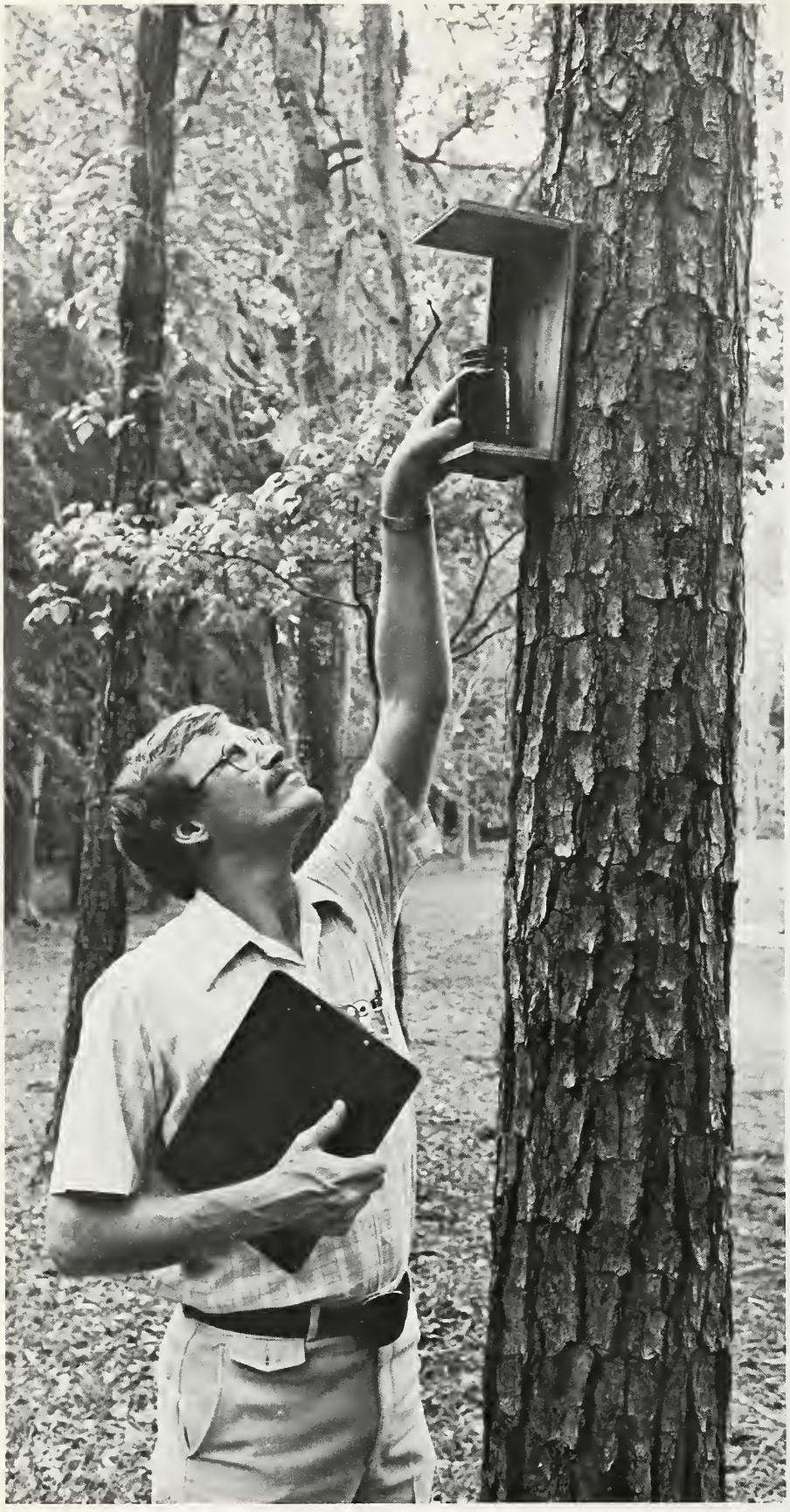
With mass rearing conditions, the larvae developed faster—in 11.1 days—and pupation was more uniform than in individual containers.

Adult females survive for 7 weeks in laboratory cages and oviposit an average of 1 egg per day.

"The amount of time larvae of *Tx. r. rutilus* can go without food may be an important parameter in biological control considerations," says entomologist Dana A. Focks. "They will be longer-lived and thus more useful."

In tests to determine this characteristic, the first two larval stages survived for about a week, and third stage larvae lived for 18 days without food. The

Thumb-top perch shows formidable size of gangly-legged 15mm long Toxorhynchites rutilus rutilus. Researchers are mass rearing Tx. r. rutilus for release in the wild in experiments to determine its usefulness against disease-bearing mosquitoes (0478X429–27A).



Dr. Focks inspects one of the 64 oviposition sites installed in and around a Gainesville residential area to evaluate searching ability of released Tx. r. rutilus. Designed to imitate the natural breeding grounds of the predator mosquito, the sites are simply dark colored glass jars partially filled with water (0478X432–18).

fourth larval stage was exceptional—larvae lived 59 days without food. "This is all the more important because this stage also is capable of eating more prey than the first three stages," said Dr. Focks.

Also important in biological control by *Tx. r. rutilus* is the existance of an oviposition stimulant. Tests showed that *Tx. r. rutilus* females preferred to oviposit in polluted water; that is, water similar to that found in natural settings (tree holes, discarded tires) rather than in such things as water barrels or discarded containers for household use. Water that had been used in rearing the prey mosquitoes was used as an oviposition media in the laboratory.

After successful colonization, 350 6-day-old, laboratory-reared adult *Tx. r. rutilus* mosquitoes were released on two different occasions into a sparsely wooded 13-acre residential area in Gainesville, Fla.

Oviposition was monitored for 14 days after each release using a grid of 64 oviposition traps within the area and 31 acres of surrounding woods. Although about 6 percent of the females migrated to the woods each day, an average of 80 percent of the eggs were laid in the residential area.

"We estimate a daily survival rate of 80 percent for the females and that each female released 4 to 5 eggs," said Dr. Seawright.

The scientists are planning large-scale field tests on the control of *Aedes aegypti* with this predator.

Dr. Dana Focks and Dr. Jack Seawright are at the Insects Affecting Man and Animals Research Laboratory, 1600 S.W. 23rd Dr., Gainesville, FL 14565. Dr. Donald W. Hall is at the University of Florida.—*P.L.G.*

Improved Orchard Heaters

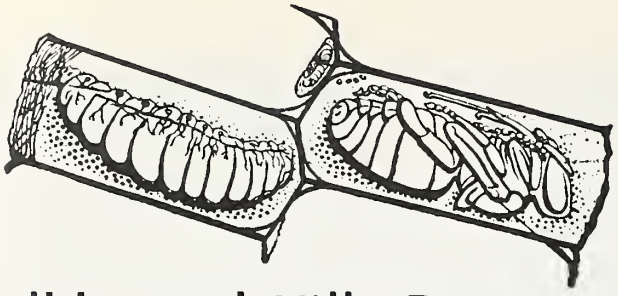
THE increasing cost of fuel is making winter freeze protection of orchards and vegetable farms prohibitive. Important fuel savings can be achieved by citrus growers if they would equip oil heaters with large diameter stack covers and fire the heaters under the trees to provide freeze protection. Heater placement relative to the trees is important in maximizing the amount of heat that can be transferred to tree parts that need protection. Researchers Benjamin G. Goodier and Paul R. Nixon also report that improved heat distribution can be obtained by using large diameter heater stack covers.

The tests were conducted in a citrus grove of relatively small 9-foot-high trees. spaced 10 feet apart within each row. Researchers used pressurized oil heaters with and without stack covers placed under and beside trees. Thermocouples were attached at various levels in the heated and unheated portions of the citrus grove to detect the temperatures. No temperature differences were noted between tests with no covers and tests with standard 13-inch covers. However, large differences in temperatures were noted when 24-inch covers were used. The larger covers distributed the heat better when used under the trees. Tree canopies captured the heat from heaters placed under them and prevented immediate dissipation. Heaters placed in the open beside a tree lost effectiveness as heated air and stack gases flowed upward out of the grove.

Although the large covers tested were made of flat aluminum sheet, conically shaped steel covers of large diameter should perform as well. Further investigations can optimize cover design, but until this is done citrus growers can realize fuel savings if they would equip heaters with larger diameter covers and place them under trees.

The tests were conducted at Texas A&M's Hoblitzelle Farms by Mr. Benjamin G. Goodier of Texas A&M University and Mr. Paul R. Nixon of the Science and Education Administration, P.O. Box 267, Weslaco, TX 78596. —*E.L.*

New, 24-inch orchard heater covers proved more efficient than the usual, smaller covers. The small metal strips on the underside of the new covers fit inside the heater and keep the covers from falling off (PN–4167).



Chalkbrood Kills Bee Larvae

CHALKBROOD, a disease of honey bee larvae caused by fungus, has spread from its first reported infection in central California in 1968 to nearly every State and six of the eight Canadian Provinces. Its rapid spread and lack of effective control is creating concern in the bee industry.

SEA scientists at Laramie, Wyo., report 50 percent brood losses from some infections, a serious financial loss for some beekeepers. However, most infections occur in less than 5 percent of all hives and only 5 percent of bee larvae in these hives are infected.

Because little is known about chalkbrood, SEA scientists are closely monitoring its spread and investigating its natural history. Presently no successful chemical control methods are available to prevent or treat chalkbrood. However, several fungicides are currently undergoing evaluation at SEA's Bee Disease Laboratory, University of Wyoming.

"Detection of chalkbrood is difficult because some bee colonies are extremely hygienic in their housekeeping and remove dead bees from hives before the infection becomes apparent," says SEA microbiologist Diana M. Menapace.

Contrary to European research, studies at SEA's Laboratory show that chilling weather is not a prerequisite for susceptibility to chalkbrood and that the disease can be found in hives any time during the year. However, chalkbrood occurs most often during spring.

"Feeding pollen cakes naturally contaminated with chalkbrood mummies and spores appears to be one of the major causes of this disease. Supplies of pollen are purchased from northern and foreign beekeepers to supplement diets of bees with inadequate pollen supplies," says SEA entomologist William T. Wilson. Even a small amount of fungus, when mixed with other supplies, will contaminate the whole shipment.

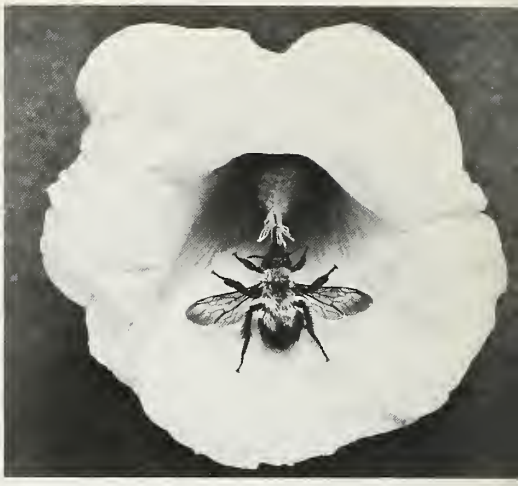
Other research from Laramie shows that queen bees fed chalkbrood fungus can pass viable spores through their digestive tracts and these spores probably in turn infect larvae.

"Presently the best control of chalkbrood is the careful selection of bulk pollen supplies and queen bees. The bee keeper would do well to purchase these from dealers who maintain disease-free hives." says Dr. Wilson.

"Our studies demonstrate that chalkbrood survives in bee colonies over the winter and continues to spread to healthy colonies the second or subsequent seasons," reports graduate student Zia A. Mehr, University of Wyoming.

The same report indicates that honey bee populations with chalkbrood in autumn have less of a chance of surviving through a cold winter.

Ms. Diana M. Menapace is at the Bee Disease Laboratory, University of Wyoming, P.O. Box 3168, University Station, Laramie, WY 82071.—*D.H.S.*



Wild bees make great pollinators

PRESENTLY few persons other than bee devotees may be familiar with the non-honey bee species, *Osmia lignaria*. But that name may soon be prominent on the lips of commercial orchard growers throughout North America because SEA tests show that the bee's potential as an orchard crop pollinator is excellent.

Until 1950, the United States and Canada maintained sufficient colonies of honey bees, *Apis mellifera*, to adequately pollinate their orchard crops. Since that time, however, many factors including intensive insecticide programs have combined to reduce the number of honey bee colonies and cause a shortage of crop pollinators. The increased market value of honey adds to the problem, as fewer beekeepers seem likely to rent their colonies for pollination purposes unless growers accept an increase in an already steep rental fee.

Furthermore, acreages of orchard crops have increased dramatically in recent years. The bloom period of these

crops is short, and the size of the plants and the amount of bloom offered by each plant is enormous. Blooming occurs early in the year when the weather is unstable and honey bee colonies are at minimal strength and hard-pressed to muster enough workers to get the job done.

With these problems in mind, SEA entomologist Philip F. Torchio, Logan, examined species of non-honey bees that visit apple and prune blooms to determine if any could be developed as a supplemental pollinator of commercial orchard crops. His study revealed that *Osmia lignaria* actually surpasses the honey bee as an orchard pollinator and is biologically more suited for the job.

Osmia lignaria nests gregariously and readily accepts manmade nesting materials so that sufficient numbers of bees can be set up to handle any size of orchard. The bee's emergence can be timed to coincide with any given orchard crop's bloom period. Maximum pollination occurs over a short period of time because of *Osmia lignaria's* short flight season and because both males and females visit orchard blooms and nest near the floral source. The bee's alacrity allows pollination to be completed between insecticide operations.

Osmia lignaria can handle a wide range of environments. Mr. Torchio's tests were conducted in Utah, near the rugged Wasatch Mountains. The insect is also doing well in similar tests currently being run on almonds in the gentle valleys of California. The bee does not seem to be locked into a single pollen host, which means that its potential as a cross-pollinator is good.

At present there is no commercial source of *Osmia lignaria*. It is a wild bee, and growers will have to trap it. However, the prodigious pollinator is found from coast to coast and is easily captured and managed.

Mr. Philip F. Torchio is at Utah State University, UMC 53, Logan, UT 84322.—*L.C.Y.*

Wizardry of *Osmia*

CALIFORNIA almond trees pollinated by the wild or non-apis bee species — *Osmia lignaria* — more than doubled the production of similar-sized, honey bee-pollinated almond trees in recent SEA cage tests.

Economics and an expanding orchard industry require that additional bee pollinator species be found to supplement honey bees on almond trees and other orchard crops (see Agr. Res., Aug., 1977, p. 12). To compare the almond-pollinating abilities of *Osmia lignaria* and honey bees, SEA entomologist Philip F. Torchio, Logan, Utah ran tests in orchards at Shafter and Turlock, Calif.

The orchards were young (trees planted in 1973) and featured intergrafted trees bearing two cross-pollinated varieties of almonds (nonpariel and 1238 at Turlock; Jefferies and 1238 at Shafter). This situation allowed for convenient construction of single-tree cages over short trees to complete cross-pollination tests.

Torchio caged four trees inside cubes of plastic screening at each location and dispersed within the cages, 10, 20, 30, and 40 female *Osmia* bees, respectively. Male *Osmia* were added at a 1:1 ratio at Shafter and a 2:1 ratio—favoring males—at Turlock. The cages prevented entrance by other insects so that any pollination taking place within was the sole responsibility of the *Osmia* bees. (Previous studies have shown that honey bees do not function well when confined because their orientation is disrupted. *Osmia* appears to have no such problem.)

At the completion of bloom, Torchio removed all of the cages. Just prior to harvest, he picked the almonds off of the trees that had been caged plus four trees of similar dimensions at each locale that—left uncaged—had been pollinated by honey bees.

After counting the nuts, de-shelling and weighing them, Torchio found that *Osmia*-pollinated trees produced 2.5 times as many nuts as honey bee-pollinated trees at both test sites. The size, shape and quality of the nuts were the same for all trees regardless of which type of bee did the pollinating. Torchio attributed the difference in yield to the fact that *Osmia lignaria* works longer hours than the honey bee and under more adverse conditions.

There was no appreciable difference in yield between any of the different combinations of *Osmia* used in Torchio's tests. In fact, Torchio believes now he could have obtained the same results with even fewer *Osmia* bees. He plans to one day determine the minimum number of bees required for adequate pollination, but his next project will probably be to isolate three orchards and pollinate one with honey bees alone, another with just *Osmia lignaria,* and a third with both to see which situation produces the best crop.

Mr. Philip F. Torchio is at Utah State University, UMC 53, Logan, UT 84322.—*L.C.Y.*

Night position of velvetleaf (PN–4164)

Day position of velvetleaf (PN–4165)

"Sleeping" Velvetleaf

SLEEPING leaves catch less herbicide than wide-awake leaves, at least in the case of velvetleaf, a serious weed in corn, cotton, and soybeans. The large circular velvetweed leaf goes through a "sleep" cycle drooping to a nearly vertical position from late evening until early morning.

"This means that the hard-working farmer who is out spraying herbicides on his fields late into the night or early in the morning will not control velvetleaf nearly as effectively as he would if he sprayed during the middle of the day," research agronomist Robert N. Andersen says.

Dr. Andersen, with USDA's Science and Education Administration, St. Paul, Minn., worked with University of Minnesota plant physiologist Willard L. Koukkari. They grew the velvetleaf plants in growth chambers providing 16 hours of light and 8 hours of darkness each day. Herbicides were applied to different groups of plants at 4-hour intervals over a 24-hour period. After treatment, the plants were kept in the greenhouse for 10 days and then evaluated for herbicide damage.

Plants treated during the dark period, when leaves were "asleep," showed as little as 28 percent damage. All plants treated during the midday period were killed.

In another test, Dr. Andersen and Dr. Koukkari sprayed velvetleaf when the plant's leaves were mechanically supported during the "sleep" period so they could not droop. Under these conditions, the scientists achieved nearly as good herbicide control at night as during the day.

The researchers also measured the amount of spray retained by velvetleaf plants at different stages of leaf droop. The amount of spray retained varied according to the leaf angle. The greatest retention of herbicide was by the most upright leaves.

"The research suggests that a major cause of the time-of-day effect in velvetleaf's response to herbicide treatment is the change in leaf orientation and the resulting change in spray retention," said Dr. Andersen.

Dr. Robert N. Andersen is located at the Department of Agronomy, Weed Research Laboratory, University of Minnesota, St. Paul, MN 55108.—*R.G.P.*

Sensoring the Sensors

"For a thermocouple hygrometer to be of value, it must give reasonable estimates of the plant's water stress or changes in stress," says SEA plant physiologist James E. Pallas.

Dr. Pallas at the Southern Piedmont Conservation Research Center and botanist Burlyn E. Michel at the University of Georgia report that a simple, stem thermocouple hygrometer is more sensitive to dynamic changes in plant-water stress than leaf hygrometers with which they were compared.

A thermocouple hygrometer utilizes a thermocouple to measure humidity that is a function of the magnitude of water stress. Either the temperature produced by water evaporating from a wet thermocouple or the dew point temperature is measured.

Leaf thermocouple hygrometers and specially-fabricated stem thermocouple hygrometers attached to peanut and soybean plants were evaluated under well-watered and drought conditions in a growth chamber. When soil-water stress was low and plant-water movement was nearly steady, the two sensors gave similar stress values.

When soil-water stresses were imposed or when plant processes varied in repeating cycles, stem hygrometers seemingly sensed the dynamic changes in plant water stress more accurately than did leaf hygrometers.

Leaf hygrometer's response lagged and any oscillations (cycling) in leaf-water potential detected were small. In contrast, stem hygrometers responded quickly and sometimes detected large oscillations in plant-water potential.

These controlled environment studies showed that, even under the best of conditions, it sometimes took several days for a leaf hygrometer to reach equilibrium.

"Interestingly, throughout our experiments with peanut plants," said Dr. Pallas, "the sensing ability of leaf hygrometers frequently differed depending upon whether they were placed on the upper or lower surface of the leaf. Although leaf hygrometer readings are out of phase with readings of the stem hygrometer, the leaf hygrometer placed on the upper surface came closer to sensing the same minimum in water potential as detected by the stem hygrometer."

Other experiments compared the two types of hygrometers on soybean plants. During two intensive experimental periods of 1 and 3 weeks duration, oscillations in plant water potential sensed by stem hygrometers were not detected by leaf hygrometers.

The scientists concluded that the stem hygrometer is more able to respond to plant-water potential change because of its close interface with stem water.

Dr. James E. Pallas, Jr. is with the Southern Piedmont Conservation Research Laboratory, Highway 53, P.O. Box 555, Watkinsville, GA 30677.—*P.L.G.*

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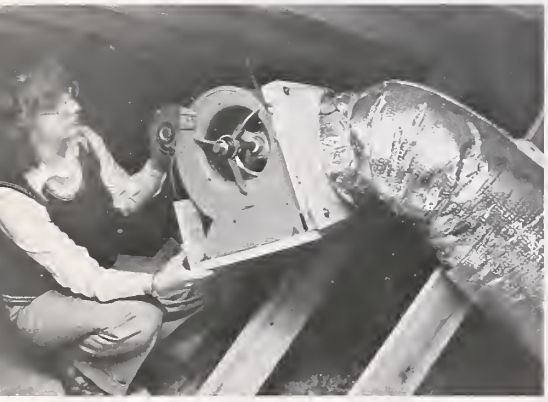
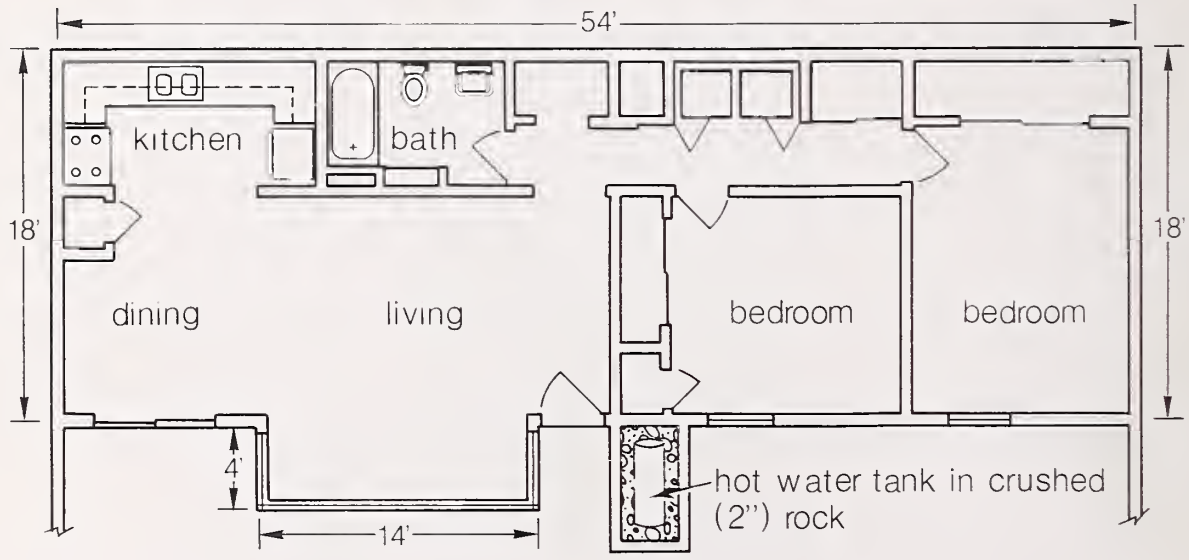
Burrowing for Comfort a

Right: A giant solar collection panel, running the length of the room, is part of the futuristic technology contemporary architecture combination that makes up this earth-insulated solar-heated house. Jearl and Avis Williams, owners of the new house, are saving energy in another way as well—as yet they have no lawn to mow. (0378X318–36).

Below: Engineering technician Kay Herlong adjusts thermostat in attic blower which automatically activates when the attic air is at a prescribed temperature. This is part of a "scavenger" heating system that takes maximum advantage of all heat in the house—especially heat that might otherwise be lost (0378X321–26A).





Floor plan for the 1,050 sq. ft. SEA experimental earth-insulated solar-heated house (PN–4166).

id Economy

A NEW look at an old idea offers opportunities for building low cost, energy-saving homes.

The old idea was that of prehistoric man who took refuge from the elements and his enemies by living in caves.

SEA and Clemson University scientists have borrowed the idea and have built an experimental solar-heated, two-bedroom home into a hillside. Only one of its walls is exposed.

Cavern living was inexpensive, but it was damp, cold, and dark. Not so the experimental house. In building it the developers took into consideration a wide variety of the needs—physical, social, psychological, and economic—of modern humans.

The exposed roof of the house bears solar collectors for effectively heating the house with solar energy.

The experimental house is wide and only one room deep. It contains 1,050 square feet and was built at a cost of approximately *$22,000*.

With the exposed wall facing south, the house is well lighted and gets the benefit of the low winter sun while north winds can pass unobstructed across the roof.

The massive soil insulation around the dug-in house provides a heat sink that can be effectively used to trap and store excess heat exhausted from kitchen appliances and bathrooms, as well as surplus heat from the solar collectors.

The roof on the house is made of conventional materials. Although an earth-fill roof could be used, it is very heavy and the necessary supporting structure would make it expensive, about four times the cost of a conventional roof. Moreover, a leak in a conventional roof is easily repaired while repairing a leak in an earth-fill roof is a major task.

The exterior walls of the house are made of pressure-treated wood, which should last indefinitely and is much more economical than masonry walls. The lightweight wood walls and foundation can be built on the ground at the

Above: *The flow rate of cool air circulated from crushed rock stored beneath the house is measured by engineering technician Roy Mundel. After being reheated by the solar collector on the roof, the air is circulated back to the crushed rock which stores the warmth for future use (0378X320–10).*

Above: *Too hot to touch? Dr. Newman judges the warmth of solar radiation passing through corregated fiberglass. Rib aluminum roofing, spray painted with a black satin finish and mounted a few inches beneath the fiberglass, will collect that warmth and further heat the slow-moving air sandwiched in between. Using ordinary carpentry skills, this type of solar collector can be built with inexpensive and easily obtainable construction materials (0977X1203–5A).*

site and tilted into position or they can be panelized under factory conditions and transported to the location for assembly.

Built near Easley, S.C. in cooperation with the owner, Mr. Jearl Williams, and the builder, Mr. Dick McConnel, the house is fully instrumented to collect performance data for a full year to determine its efficiency. A second generation model will be built on the Clemson University dairy farm during the spring and summer of 1978.

Responsible for the design are agricultural engineers Dr. Jerry O. Newman and Mr. Luther C. Godbey, SEA Rural Housing Research Unit, P.O. Box 792, Clemson, SC 29631, and Assistant Professor of Architecture Martin Davis, Clemson University, Clemson, SC 29631.—*V.R.B.*

Above: *Nerve center: inside the instrument shed engineering technician Kay Herlong marks and dates readouts generated by various temperature-sensing devices strategically located in and around the house. Continuous records are kept for available solar energy as it relates to soil and rock storage temperatures, plus temperatures in the hot water tank, the attic, inside and outside the house, and in the solar collector (0378X319–10A).*

Below: *Soil temperature changes at progressive depths and distances from the house are detected as voltage changes by "sensing stakes" and relayed to a potentiometer (like a voltmeter) in a nearby instrument shed. Each stake has 10 thermocouples buried at 1 foot intervals, and engineering technician Kay Herlong must individually connect each thermocouple to the potentiometer for a separate reading. The procedure is repeated daily for three series of stakes running in different directions. (0378X317–18A).*

Sugar reduces chick mortality

SWEETENING the first water they drink will reduce the mortality of broiler chicks.

In six experiments involving over 20,000 broiler chicks, SEA animal nutritionist James L. McNaughton found that giving the chicks an 8 percent sucrose solution during the first 15 hours of their lives was beneficial.

Dr. McNaughton found that the sucrose solution, with or without feed, decreased chick mortality from the average of 4.60 to 2.92 percent.

Whether the chicks got feed or didn't during the first 15 hours had no effect on mortality, and the early sucrose treatment had no effect on the later body weight of the broilers.

The scientists also found that when a sucrose solution is injected beneath the skin of the chicks, as well as provided in their first drinking water, mortality is even further reduced.

Earlier studies by Dr. McNaughton had shown that body fat was lowest in 1-day-old broiler chicks hatched from eggs laid by young breeder flocks. He believes that the sucrose supplements the chicks' energy supply and helps them survive.

Dr. James L. McNaughton is located at the South Central Poultry Research Laboratory, Mississippi State, MS 39762.—*B.D.C.*

Plants with Built-in Resistance

WHILE more than a million insect species exist, only a few thousand may be classified as pests. Only about 500 of these species cause significant crop damage. Nevertheless, insect damage to field and vegetable crops is estimated at more than $1 billion annually, in spite of the fact that every year 500 million pounds of insecticides are used for insect control.

But Mother Nature has helped out. Nearly 1,500 plant species contain naturally-occurring chemical compounds that are toxic to insects. Knowledge of these compounds would play an immense role in future plant breeding programs.

"Built-in resistance is the most economically and ecologically sound of all possible methods for controlling insect damage. This method will give us another weapon to use against insects and decrease our dependence on pesticides and cultural practices. Plants with built-in resistance have chemicals toxic to insects right where they are needed . . . on the plants," says chemist Anthony C. Waiss, Jr., at SEA's Western Regional Research Center.

Isolation of chemicals toxic to insects would aid plant breeders in selecting those varieties containing the highest content of insect toxicants.

Research on host plant resistance, as it is known, is not new. Resistance to insect attack was reported in the 1700's, but strong support for such research did not develop until the 1950's. Since the fifties many breeders, geneticists and entomologists have studied resistance but few at the basic chemical component level. Studies at the Center are aimed at identifying those naturally-occurring chemicals that impart insect resistance to plants.

Condensed tannin, naturally present in cotton plants, may protect cotton against attack by the tobacco budworm (*Heliothis virescens F.*). Studies at the Center show that when tannin was added at the rate of 0.3 percent of a diet, larval growth, percent pupation and moth emergence were significantly reduced compared to larvae not fed with tannin.

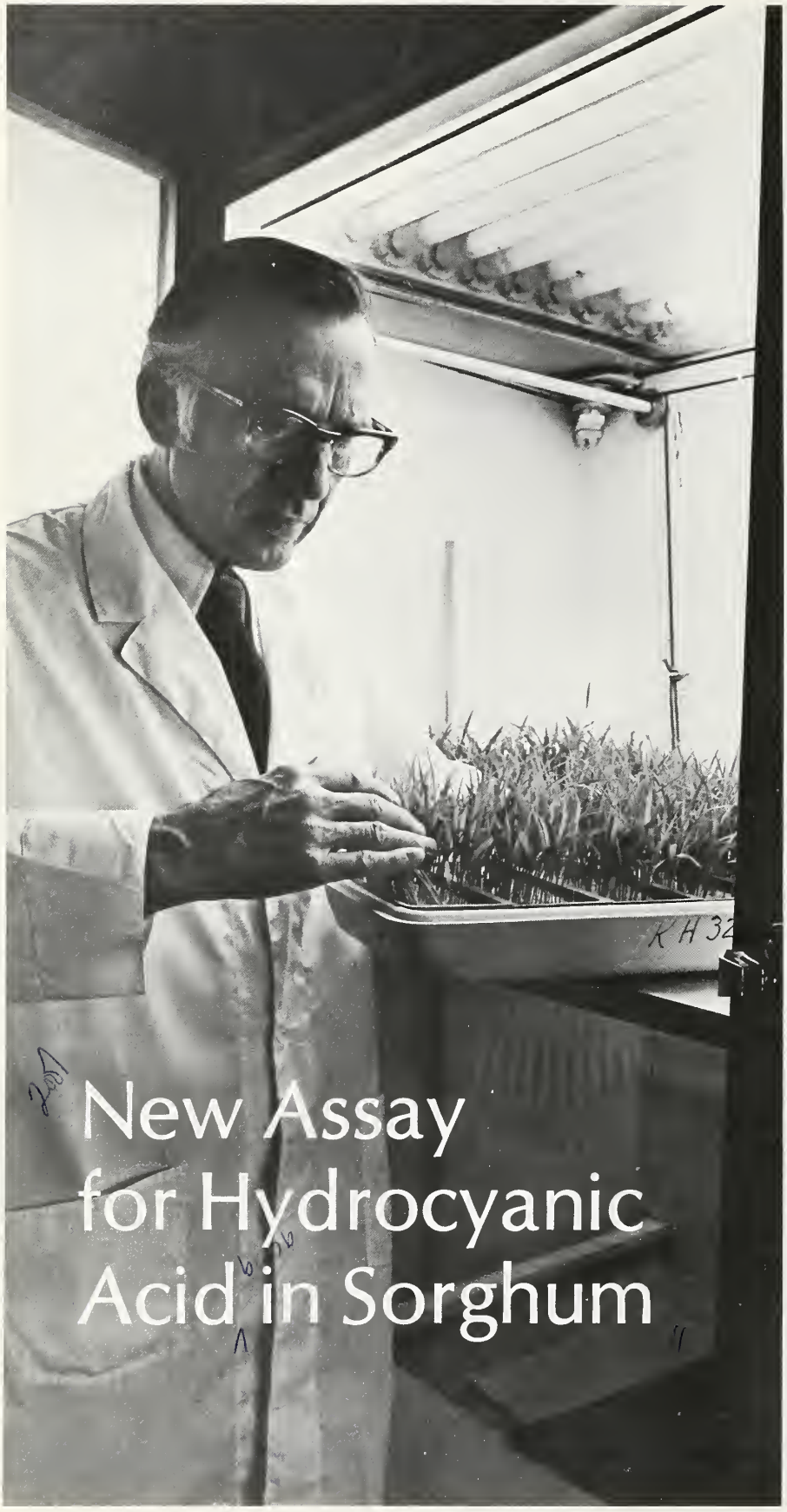
Similar studies on corn's resistance to attack by corn earworm (*Heliothis Zea B.*) indicate that the naturally-occurring toxic compounds in corn are polyphenols. Other studies show that diterpenoic acids may play a very important role in protecting sunflowers from sunflower moths (*Homeosoma electellum H.*)

One of the interesting facts emerging from these results is that, in contrast to chemical pesticides, naturally-occurring resistant compounds are more selective in their toxicity to insects, and are strategically located to affect their target insects. Nature has designed a delivery system so effective that plant parts consumed by humans either do not contain the resistant compounds found so far or they contain only insignificant amounts.

"While specific chemicals are important in natural insect resistance, many additional factors play important roles too. Among these are: insect feeding behavior; age, physical structure and condition of plants; cultural practices; and the environment," says Dr. Waiss.

Many scientists are cooperating on this project, both with SEA and State Agricultural Experiment Stations across the country.

Dr. Anthony C. Waiss, Jr. is with SEA's Western Regional Research Center, 800 Buchanan Street, Berkeley, CA. 94710.—*D.H.S.*



New Assay for Hydrocyanic Acid in Sorghum

ALL sorghums contain dhurrin, a compound that yields hydrocyanic acid when broken down by an enzyme—under some conditions in amounts fatal to grazing livestock.

Progress in selective breeding to lower dhurrin content in forage sorghum and sudangrass has been restricted by limitations of methods for screening experimental lines. A technique developed at Lincoln, Nebr., may remove that roadblock to progress.

Sampling plants for assay or assessing hazards to grazing livestock is complicated by dhurrin content variations related to growth stage or environmental conditions. SEA geneticist Herman J. Gorz says dhurrin content declines as sorghum plants mature, is generally highest in new growth, and may be increased by drought stress, high nitrogen fertility, or frost.

Grazing sudangrass when the crop is less than 18 to 24 inches high and after stress should therefore be avoided to restrict the possibility of what is commonly called prussic acid poisoning.

Dr. Gorz explains that hydrocyanic acid is bound in the dhurrin molecule until it is released by an enzyme in the plant or the rumen. Assay procedures determine hydrocyanic acid potential—the amount that will be released when the molecule is broken down into hydrocyanic acid, glucose, and *p*-hydroxybenzaldehyde.

Early assay procedures involved enzymatic or chemical release of hydrocyanic acid as a gas, but these techniques are time-consuming and may be inaccurate because of incomplete release or incomplete recovery of the gas. Unidentified interfering compounds may complicate measurement with a cyanide-specific electrode, and determining low levels is sometimes difficult.

The spectrophotometric assay devel-

Dr. Gorz examines test seedlings nurtured in a germination chamber. Growing conditions must remain consistently at 27° C with continuous light (0178X 113–13A).

Above: *After breaking down the dhurrin, Dr. Specht runs samples through a spectrophotometer. Hydrocyanic acid content of each variety of sudangrass is related to the amount of p-hydroxybenzaldehyde, as measured by the spectrophotometer (0178X112–30).*

Left: *Dr. Haskins (left) and Dr. Gorz collect random samples of sudangrass for an assay of dhurrin content. The samples are weighed, then placed in test tubes of water and heated in an autoclave. Heating extracts the dhurrin from the leaves and then separates it into glucose, cyanide, and p-hydroxybenzaldehyde—the latter of which is measured to determine cyanide content (1078X110–17).*

oped by Dr. Gorz and agronomists William L. Haag, James E. Specht, and Francis A. Haskins of the University of Nebraska measures *p*-hydroxybenzaldehyde rather than hydrocyanic acid. The conversion to content of hydrocyanic acid is easily made, since relative amounts of each in the dhurrin molecule are known.

Two observations suggested a new method for uniformly and efficiently analyzing plant tissue. The researchers found that dhurrin can be simultaneously extracted and broken down into its three components by autoclaving tissue in water. Other studies revealed that hydrocyanic acid potential of the first seedling leaf to emerge remains relatively constant for the first 15 days and is higher than that from other parts of the seedling.

Dr. Gorz says the assay is rapid, requires only the first leaf (so the plant is not destroyed), and avoids limitations of methods in which dhurrin is broken down by an enzyme. Spectrophotometric readings for *p*-hydroxybenzaldehyde are made after extracts obtained by autoclaving the first leaf in water are diluted into a basic solution, such as sodium hydroxide. Hydrocyanic acid potential is then calculated.

Comparative spectrophotometric readings confirmed that what is measured in autoclaved extract from a sorghum leaf is *p*-hydroxybenzaldehyde. In addition, the ranking by spectrophotometric assay of 37 sorghum and sudangrass varieties or parent lines agreed well with ranking by other investigators who used different assay techniques.

Piper sudangrass was the lowest-ranked variety by the assay, and it is acknowledged to be the lowest in hydrocyanic acid potential among widely used varieties. Two experimental sudangrass lines developed by Dr. Gorz and his coworkers by use of the spectrophotometric assay were even lower in hydrocyanic acid potential than Piper.

Dr. Herman J. Gorz is located at 329 Keim Hall, University of Nebraska, Lincoln, NE 68583.—*W.W.M.*

Possible Drug Therapy for Mastitis

LABORATORY studies suggest the possibility of drug therapy for the acute form of bovine mastitis.

More than 90 percent of 214 cultures of bacteria responsible for acute mastitis were sensitive to 3 of 17 antimicrobial agents tested by veterinary medical officer John S. McDonald of USDA's Science and Education Administration. His study also confirmed that these bacteria are relatively insensitive to the four agents which have been approved by the Food and Drug Administration (FDA) for infusion into the bovine mammary gland.

The three showing promise in the study—chloramphenicol, gentamicin, and polymyxin B—are not approved by FDA for this use. Research demonstrating their effectiveness in treating cases of acute mastitis and providing data on residues in milk would be needed before approval for use could be considered, Dr. McDonald points out.

Penicillin, streptomycin, neomycin, and nitrofurazone, which have FDA approval, are useful for treating chronic mastitis caused mainly by streptococcal and staphylococcal bacteria.

Acute mastitis, caused by *Escherichia coli, Klebsiella,* and other species, may flare up suddenly. The endotoxin produced in the milk is absorbed into the blood, causing high fever, temporary destruction of the body's ability to fight infection, and damage to small blood vessels.

Dr. John S. McDonald's address is: USDA–SEA, National Animal Disease Center, P.O. Box 70, Ames, IA 50010.—*W.W.M.*

Dichlorfop-methyl Controls Wild Oats

ACTION of the experimental herbicide dichlorfop-methyl on plants is like the quick one-two punch of a boxer.

The first blow does minimal damage to wheat but figuratively staggers wild oats, the weed most difficult to control in wheatfields of northern United States and Canada. The followup punch bounces off wheat without harm but completes the knockout of wild oats. Dichlorfop-methyl is not registered for commercial use.

The herbicide has two biologically active forms, says plant physiologist Richard H. Shimabukuro, affecting different sites in susceptible plants. Dichlorfop-methyl, the ester form, inhibits plant growth. Dichlorfop, the acid form, destroys cells by damaging their internal structure.

Wheat is highly tolerant of the herbicide and both wild and cultivated oats extremely sensitive, even though wheat and oats are closely related plants and grow under the same conditions.

The herbicide's selective action is explained in studies involving Dr. Shimabukuro, visiting Romanian plant physiologist A. G. Brezeanu, plant physiologist David G. Davis, chemist Wendy C. Walsh, and technician Roland A. Hoerauf at the Metabolism and Radiation Research Laboratory (MRRL), Fargo, N. Dak., and plant physiologists Mary A. Shimabukuro and William S. Nord at Moorhead State University, Moorehead, Minn.

Dichlorfop-methyl is quickly converted to the other active form, dichlorfop, by both wheat and wild oats. Then both plants inactivate dichlorfop, producing different end products.

The same concentration of dichlorfop-methyl inhibited elongation of coleoptile segments by 51 percent in oats and only 13 percent in wheat. Dichlorfop also reduced coleoptile elongation 23 percent in oats but did not affect it in wheat. This test showed that the herbicide is an auxin antagonist, interfering with stimulation of cell elongation by the plant hormone indoleacetic acid. This results in the stunted growth of wild oat plants.

In addition, both active forms of the herbicide inhibit root growth in oat species but not in wheat. Dichlorfop was a more effective inhibitor of primary and secondary root growth in oats than was dichlorfop-methyl in the Moorhead studies.

The herbicidal effect is therefore the net result of both active forms damaging susceptible species. Wild oats is about four times as sensitive as wheat to growth inhibition by dichlorfop-methyl. The other active form, dichlorfop, then strikes at roots as well as stems of sensitive wild oats but is not damaging to resistant wheat.

The first symptoms of injury in young seedlings were seen about 4 days after treatment with dichlorfop-methyl. Only the second leaf was affected on wheat but both the second and emerging third leaf on wild oats. Growth was inhibited in wild oats but not in wheat.

Electron microscope examination of affected leaves from these plants indicated treatment had accelerated the process of senescence, or aging, especially in wild oat cells. In wild oats many cells were damaged, and the extent of alteration was frequently more severe than in wheat cells.

Dr. Richard H. Shimabukuro is at the Metabolism and Radiation Research Laboratory, P.O. Box 5674, Fargo, ND 58102.—*W.W.M.*

SEA Geneticist E. C. Bashaw examines buffelgrass rhizomes (essential for cold tolerance) and seed heads (1077A1450–36).

Wider Area for Buffelgrass

BUFFELGRASS specimens gathered on an expedition to the Union of South Africa may double the range of this forage grass by extending it to 10 million additional acres of Texas rangeland.

Buffelgrass, introduced into this country from Southern Africa in 1948, is extremely drought resistant and, unlike native grasses on semiarid ranges, can withstand continuous grazing. Buffelgrass has an asexual method of reproduction called "apomixis" (Agr. Res. Mar., 1967) that makes possible true-breeding hybrids.

"Buffelgrass," says SEA geneticist E. C. Bashaw, "evolved under different conditions from those of native grasses which were grazed infrequently by migrating herds of buffalo. In Southern Africa, where buffelgrass evolved, the grass was subjected to continuous grazing by several different species of animals."

Buffelgrass is already well established on rangeland south of San Antonio and into eastern Mexico where it produces a good, palatable forage.

Dr. E. C. Bashaw and SEA agronomist Dr. A. J. Oakes, Jr. traveled some nine thousand miles over a period of 3 months to collect 700 specimens of the African grass.

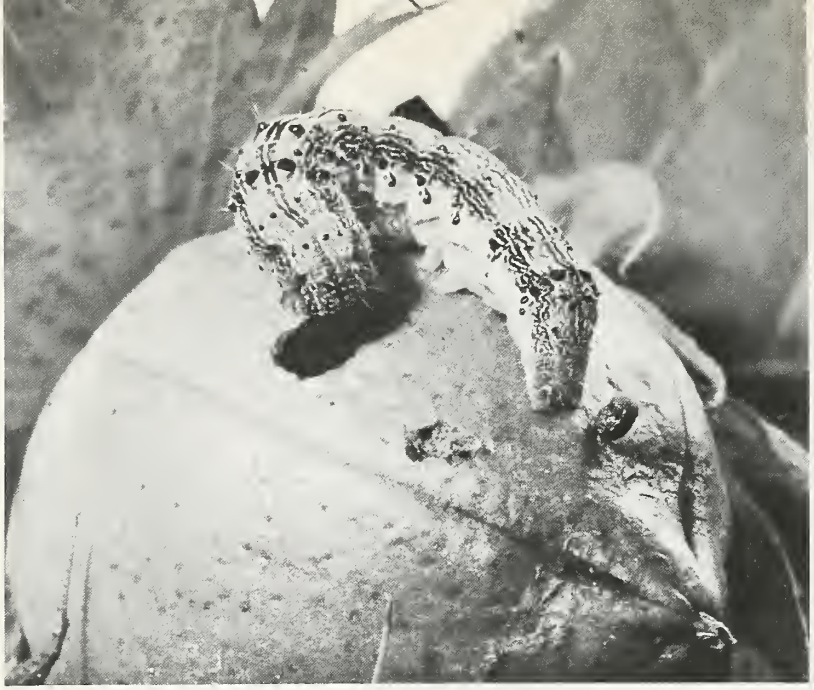
The researchers hope to extend the range of the grass northward in Texas from San Antonio to Abilene or, roughly, to double its present range.

One of the main qualities that the researchers are looking for is cold tolerance, and the scientists have very promising material. Some of the plants were collected at high, cold altitudes.

Buffelgrass adapts to cold by well-developed rhizones (rootstalks); however, the ideal plant that the researchers are seeking must also produce a good head of seed for reproduction. This combination has eluded researchers in the past, but with their new African material, they expect to attain the combination they need.

"We believe we have the material," says Dr. Bashaw, "to develop the ideal drought-tolerant, good-yielding, and cold-resistant buffelgrass."

Dr. Elixis Bashaw is the Research Leader of the Crops Genetics and Improvement Research group, Texas A&M University, College Station, 77843. Dr. Albert J. Oakes, is with the SEA Germplasm Resources Laboratory, Room 332, Building 001, BARC–West, Beltsville, MD 20705—*B.D.C.*



Tobacco budworm, Heliothis virescens, on cotton boll. (771K926–4).

Sterile Tobacco Budworms

MOTHER nature may be an ally of researchers seeking to control the tobacco budworm, *Heliothis virescens*, a serious pest of cotton.

The mating of tobacco budworm males to females of a related species, *H. subflexa*, in laboratory experiments produces progeny in which the male is sterile and the female fertile. Wild ground cherry plants are the host of *H. subflexa*. When the hybrid female mates with the male tobacco budworm, sterile males and fertile females result. These hybrids may be useful in pest control programs.

Researchers Sammy D. Pair, Marion Laster, and Dial F. Martin report that the first generation (F_1) offspring resulted in a bizarre insect, but backcrossing the F_1 female to male tobacco budworms produces hybrids that behave like normal tobacco budworms in the laboratory. Further, their research reveals that the hybrid female carries the trait for male sterility and this trait is persistent in subsequent backcross (BC) generations when BC females are mated with normal males.

Limited field studies indicate that when released in the wild, BC females compete with normal females for fertile matings. Theoretical calculations indicate that if released in adequate numbers, moths carrying the sterile male trait would eventually suppress populations of native tobacco budworms.

Pilot studies involving the monitoring of native tobacco budworm populations on St. Croix, VI, will spur field tests there to evaluate the effectiveness of the sterile hybrid concept for tobacco budworm control. If successful, cotton growers will have a new biological control weapon in the ceaseless war on pests of cotton.

Mr. Sammy D. Pair and Dr. Dial F. Martin are located at the Bioenvironmental Insect Control Laboratory, P.O. Box 225, Stoneville, MS 38776. Dr. Marion L. Laster is with the Delta Branch of the Mississippi Agricultural and Forestry Experiment Station, Stoneville, MS 38776.—*E.L.*

AGRISEARCH NOTES

Soybean Yields Improve

SOYBEAN varieties that farmers planted in 1971–73 produced average yields of 27.7 bushels per acre nationwide. Those yields were 145 percent greater than average yields in 1924–26. SEA scientists have asked themselves how much of the increased yields can be attributed to soybean breeding and how much can be attributed to such improved management as better weed control and fertility.

Studies by SEA agronomist Virgil D. Luedders, Columbia, Mo., have indicated that breeding played no small role. Yield tests that Dr. Luedders conducted near Columbia showed that modern varieties outyielded varieties in the 1920's and 1930's era by an estimated 45 percent when the new and old varieties were grown under the same cultural practices. The 3-year study, which involved 21 varieties, also showed that modern varieties generally lodged (fell over) about 40 percent less than soybean varieties of the 1920's and 1930's era.

The new varieties grew to an average height of 85 centimeters (cm) or 33½ inches. That's 6 cm or nearly 2½ inches taller than the average height of the old varieties.

About a third of the varieties in the study were first planted by farmers in the 1940's and 1950's. These varieties yielded about 29.2 bushels per acre, or

26 percent more than older varieties. Varieties that were developed in the 1960's produced average yields of 33.8 bushels per acre in the test plots.

Dr. Virgil D. Luedders' address is: USDA–SEA, Room 210B Waters Hall, University of Missouri, Columbia, MO 65201.—*G.B.H.*

High Protein Wheat

NEW LINES of spring wheat, the results of high protein genotype crosses, boast an average increase of 2.5 percent in protein content and 12.0 grams per 2.4 meters of row in protein yield over the parent wheat varieties.

The importance of protein in the human diet has triggered a great research effort to improve the nutritive value of cereal crops by increasing grain protein content without sacrificing grain yield.

Based on thousands of protein and bread-baking tests, SEA agronomist F. Harry McNeal, along with Charles F. McGuire and Marvin A. Berg, of Montana State University at Bozeman, selected nine high protein wheat genotypes from eight foreign countries and crossed them with each other and with proven U.S. varieties. From each of these crosses, the two highest protein lines were selected and crossed once again with each other.

The 27 highest protein wheat lines from this second crossing will be good tools for wheat breeders, serving as sources of high protein germplasm for those researchers who wish to increase the protein levels of current, commercial wheat varieties or to develop new, improved varieties. Though expected to be very useful as breeding tools, the new lines are poor from an agronomic standpoint—producing weak straw and displaying poor field characteristics.

"These new lines could have an impact on commercial wheat varieties 10 years from now," says McNeal, "but they are available to breeders right now and they could influence present varieties."

Wheat breeders interested in obtaining material from lines can contact Dr. F. Harry McNeal at Room 311, Johnson Hall, Montana State University, Bozeman, MT 59717.—*L.C.Y.*

Blue Flu Attacks Bollworms

A NATURALLY occurring iridescent virus affecting bollworms (*Heliothis Zea*) may one day be instrumental in controlling this pest of cotton. The virus was discovered in bollworm larvae collected on crimson clover and vetch growing on a road right-of-way in Bolivar County, Miss. The virus was isolated and purified from the collected larvae.

Experiments involving ingestion and injection of the virus by bollworms reveal that injection of diluted purified virus consistently produced the characteristic iridescent lavender-blue, blue, blue-green color symptoms and caused paralysis and death of all injected insects. Most larvae exhibiting these symptoms stop feeding, burrow into their laboratory diet (their feeding medium) and gradually die. The few that do not die in the larval stage develop into grotesque pupae and then die.

Ingestion of the virus did not result in transmission. Some suggest that natural transmission may occur as a result of cannibalism. Others believe that the presence of iridescent virus in the larvae is related to larval parasitism, perhaps by a nematode belonging to the family Mermithidae and the genus Hexamermis which has observed to be associated with larval infection in nature.

Further research may reveal how the iridescent virus can be used to effectively combat bollworms in cotton fields.

Dr. Earl A. Stadelbacher, discoverer of this virus in bollworms, is located at the Bioenvironmental Insect Control Laboratory, P.O. Box 225, Stoneville, MS 38776. His collaborators, Dr. Jean R. Adams, Dr. Robert M. Faust, and Mr. George J. Tompkins, are at the Agricultural Research Center, Insect Pathology, Beltsville, MD 20705.—*E.L.*

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AGRISEARCH NOTES

Rice for Beer Lovers

BEER LOVERS everywhere will revel in the knowledge that their favorite brew will flow undiminished as a result of new rice variety LA 110. This variety helps fill the starch requirements of breweries preferring to use rice instead of corn grits.

Demand for a suitable source of starch to supply the needs of the brewing industry in the U.S. has increased greatly in recent years; this upward trend is expected to continue. Projections suggest that demand will exceed the supply of brewer's rice by 50 percent. Because of limited availability of domestic brewer's rice, rice imports have been relatively high. The loss of foreign exchange resulting from purchase of imported rice helped emphasize the need for domestic sources of brewer's rice.

Researchers working in cooperation with the Louisiana State Agricultural Experiment Station used a cross between two rather recent rice introductions to develop LA 110. With only 2 test years of data available, the winter nursery in Puerto Rico was instrumental in accelerating seed production by extending the growing season. Seed rice growers aided in large-scale production of this new variety.

LA 110 is unique in being the first semi-dwarf rice variety released in the U.S. Its high yielding capacity and resistance to all races of blast currently known to affect rice in the U.S. make it an excellent germplasm source for use in breeding programs.

Dr. William O. McIlrath is with the Science and Education Administration, USDA. Mr. Earl A. Sonnier, Mr. Gerald J. Trahan, and Dr. Nelson E. Jodon are with Louisiana State University. All are located at the Louisiana State University Rice Experiment Station, P.O. Box 1429, Crowley, LA 70526.—*E.L.*

Pest-resistant Tobacco

GENETIC manipulation of tobacco plants by plant breeders has had a major role in the development of high quality tobacco. Disease and pest resistance, improved leaf quality, alteration of levels of chemical constituents, and the development of plants amenable to mechanization are all the result of genetic manipulation.

Recent research reveals that tobacco introduction 1112 is resistant to two pests, the tobacco budworm and the green peach aphid. In field and laboratory tests tobacco budworms laid far fewer eggs on TI–1112 plants, and green peach aphids simply left the plants. TI–1112 consistently suffered light damage from tobacco budworms and had few colonies of green peach aphids. Flue-cured tobacco in the same field was heavily infested with green peach aphids.

Lack of glandular leaf hairs on TI–1112 plants may be in part responsible for resistance to tobacco budworms and green peach aphids. The resistance is apparently based on the response plant colors produce in adult insects according to researchers Kent D. Elsey and James F. Chaplin of the Tobacco Research Laboratory, Rt. 2, Box 16G, Oxford, NC 27565.

The lack of glandular leaf hairs, which exude a sticky substance, has also encouraged parasitism by *Trichogramma* wasps. The tiny wasps are better able to parasitize tobacco budworms without interference from the sticky substance found in plants with glandular leaf hairs.—*E.L.*

When reporting research involving pesticides, this magazine does not imply that pesticide uses discussed have been registered. Registration is necessary before recommendation. Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if not handled or applied properly. Use all pesticides selectively and carefully.

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